# Weed Management

## for Hops

HĀPI
HOP RESEARCH CENTRE

First published January, 2020

Third party images used in this publication are acknowledged accordingly. All other images were taken by Katherine Dunbar.

# Preface

E ngā iwi, e ngā reo, e ngā kārangarangatanga maha tēnā koutou katoa.

*To the peoples, to the many voices, we greet you all.*

Tēnei mātou te mihi atu ki a koutou i roto i ngā tini āhuatanga o te wā. He kairangahau hāpi (hops) mātou nō te pūtahitanga o Hāpi, e kimi nei, e hāhau nei i ngā momo hōu, i ngā huarahi hōu e tupu ai te ahumahi hāpi o Aotearoa ki tōna teitei.

*We acknowledge you and your ancestors, and all of the things happening in our various worlds.*

*We are researchers into hops, from the research collective known as Hāpi, who are seeking out new varieties and methods of hop farming, to ensure the hops industry of New Zealand grows to its full potential.*

E ū ana mātou ki ngā upoko o te Tiriti o Waitangi i roto i ā mātou mahi, ā, ka anga te titiro ki ngā iwi o te Tauihu o Te Waka, o te Upoko o Te Ika, otira ngā iwi katoa, e kui mā, e koro mā tēnā koutou katoa. Ko te hiahia kia haere ngātahi tonu ā tātou mahi kia puta he oranga mō ngā uri whakatupu.

*We affirm our commitment to the pledges of the Treaty of Waitangi in our work, and in so doing acknowledge the people of the top part of the South Island and the lower North Island where we have a presence, to all the elders, sincere greetings. Our wish is to work in tandem with you in developing the industry for the benefit of coming generations.*

E mahi tahi ana mātou me ngā kaipupuru pānga o Moutere, o Pōneke, me ētahi atu takiwā, me te Manatū Ahu Matua, i runga anō i te hiahia kia puta he he hāpi, he pia ahurei, nō Aotearoa anake, ka paingia e ngā iwi o te motu, o te ao, e tupu ai he huanga ā-ōhanga mō te katoa.

*We work closely with our shareholders in Moutere, Wellington, and elsewhere, and with the Ministry for Primary Industries, with the common aim of producing uniquely New Zealand hops and beer which people nationally and internationally will enjoy, producing an economic benefit for the whole country.*

Te mahi a te kotahitanga o Hāpi he whakahīato i te tangata, he whakawhiti mōhiotanga, he tūhura huarahi hou, ā, i te mutunga, he whakatupu i ngā hāpi pai rawa o te ao katoa.

*Hāpi collective is about gathering people together, exchanging information, exploring new ways of working and in the end, producing excellent hops for the whole world.*

New Zealand hop production encompasses only a small fraction of the global market; however, hops from New Zealand are highly sought after by domestic and international craft brewers. At the end of 2018 we launched Hāpi Research Ltd, with the vision to transform New Zealand's hop industry into a significant direct supplier of super-premium hops to the best craft breweries in the world. Our goal is to grow the value and volume of New Zealand premium craft beer and hop sales domestically and internationally, and to help New Zealand craft brewers create sustainable points of difference and access attractive new markets.

Hāpi Research Ltd. is a new collaborative industry-led hop breeding and market development company that seeks to support the growth of New Zealand craft beer and hop farming. We are doing this through the Hāpi - Brewing Success programme between Hāpi Research Ltd and the Ministry for Primary Industries. This programme is driving benefits for New Zealand's premium hops and craft beer industries through an advanced market-led hop breeding programme, precision farming and processing techniques, and international market collaboration with leading craft brewers.

Hāpi Research hosts an annual symposium, a gathering of craft beer and hop industry participants from across the globe, for a day of talks covering the latest research from the hop world, brewing techniques, and experiences from breweries and other industries. The event creates opportunities to build stronger, direct relationships, share best practices, and hear about the latest in hop research, brewing techniques, and market tastes and trends. The Hāpi Symposium provides a forum for domestic and international craft brewers, scientists, hop breeders and growers to engage in collaborative discussions, information sharing, and networking.

Hāpi Research is striving to create a platform for facilitating industry excellence and to become a resource centre for industry best practices in hops and craft beer. We aim to become a resource for new innovations, the latest research, and sustainability best practices. We strive to be a source of quality information on the hops and craft beer industries and to create opportunities to connect New Zealand craft beer and hop industry participants to markets.

This guide is intended to provide general information about weed management for hops. The Hāpi Research website is also a valuable source of information and has useful and relevant resources. We continuously add to this material and strive to provide up-to-date and relevant information. Please visit the Hāpi Research website at Hapi.co.nz for more information and to access additional resources.

Cheers,

The Hāpi Team

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HOP RESEARCH CENTRE

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# Purpose of this Guide

The purpose of this guide is to provide general information on weed management and the use of weed management strategies with hops. Recommendations vary by region, irrigation method, soil type, and other factors, and are not part of the scope of this guide. It is important to consult an expert to determine an appropriate weed management plan for your region and situation.

# Introduction

The term weed is commonly used to describe a plant growing in an unwanted location, such as a farm field, garden, or lawn. In New Zealand, the term pest plant is a commonly used to describe weeds. Although New Zealand has a number of native weeds or pest plants, many weeds growing among crops or in gardens throughout New Zealand were introduced either accidentally or in some cases deliberately by British settlers in the 1800s.[i] Weeds are estimated to cost the New Zealand agricultural sector millions of dollars each year in lost production and cost of control.

Weed management is an important component of hop garden management, and will impact both hop growth and yield. Weeds compete with the hop plants for both nutrients and light. In addition, when weeds are not properly managed in a hop garden, it creates an environment where pests and disease can thrive. Excessive weeds in a hop garden also interfere with ongoing farm management activities such as spraying, training and harvesting. It is therefore important to have an effective weed management plan to control and keep weeds to a minimum.

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# Types of Weeds

There are a variety of weed types that can be present in a hop garden and proper identification is necessary for the development of an effective strategy for weed management and control. Accurately identifying the types of weeds in your hop garden is critical to understanding their growth habits and in determining appropriate management and control methods for the weeds that are present.

Most weeds in a hop garden are either annuals, biennials or perennials.

## Annuals

Annual weeds grow from seeds dropped in the previous growing season. Annuals are easiest to control in the seedling and early vegetative stage, and control becomes increasingly difficult as the plants increase in size.[ii]

Summer annual weeds emerge in the spring, set seeds in later summer and then die in the autumn.[iii] Summer annuals are dominant between the spring and autumn, when they are killed by autumn frosts.

Winter annual weeds produce a rosette of leaves in the autumn, go dormant in winter, and resume growth in spring.[iv] Winter annual weeds have little direct impact on hop growth, but they deplete soil moisture and interfere with hop garden maintenance operations, in addition to harboring pests and disease.[v] Winter annuals prefer cooler temperatures with abundant moisture. Winter annual weeds won't germinate until the soil temperature and/or the day length begins to decrease.[vi]

## Perennials

Perennial weeds are weeds that live longer than 2 years. These weeds reproduce vegetatively by horizontal shoots, rhizome, and seeds.[vii] Perennial weeds can be hard to control and are often spread by tillage activities. It is crucial to control perennial weeds prior to planting a hop garden as they become increasingly difficult to manage once a garden is established.

Seed germination in perennial weeds is triggered when the soil reaches a certain temperature.

## Biennials

A biennial weeds live longer than 1 year and are generally less common that annuals or perennials. Biennials take two years to compete their lifecycle. Biennial weeds grow vegetatively in the first year then flower and die in the second year.[viii] Biennials are easiest to control during the seedling and rosette stages. Once the plants begin to set seeds in the spring, control becomes increasingly difficult.[ix]

## Common Weeds on New Zealand Farms

Weeds are prevalent in New Zealand and commonly grow among crops, interfering with crop growth and yield, and provide a haven for pests and disease. Some common weeds found throughout New Zealand include: groundsel, chickweeds, fathen, nightshades, amaranth, and willow weed.[x]

### Groundsel

Groundsel is an annual weed that completes it lifecycle quickly, often in seeding within 5-6 weeks of germination.



[xi]

## Chickweeds

Chickweed is a small annual weed that can germinate and grow at any time of the year.

 [xii]

## Fathen

Fathen is a summer annual that is one of the most competitive cropping weeds in New Zealand.

 [xiii]

## Black Nightshade

Black Nightshade is a summer annual that grows quickly.

 [xiv]

## Amaranth

Amaranth is a summer annual that has widely spread throughout New Zealand.

 [xv]

## Willow Weed

Willow weed is an annual that thrives in moist soil conditions. Willow weed is problematic in most areas of New Zealand, and is usually prevalent in the spring and dies off in autumn.[xvi]


[xvii]

## Broad-Leafed Dock

The broad-leafed dock is the most common weed found on New Zealand farms. This weed is a perennial with a strong, thick taproot, which allows for easy regrowth. Docks are generally difficult weeds to kill, and often have a mild tolerance to herbicides. Control is achieved by the combination of various herbicides.[xviii]


### California Thistle

California thistle is one of the most common thistle species in New Zealand and is difficult to control. California Thistle is a perennial weed that grows and spreads in patches, and has a spreading underground root system. The root system is easily broken up by cultivation and spread, creating larger infestations.[xix] The use of herbicides is the most effective means of control for California Thistle.[xx]


[xxi]

## Weed Seed Germination

Weed seed germination is triggered by temperature, moisture, and hop garden operations that expose the seed to light.[xxii] Not all the weed seeds present in the soil will germinate each year due to dormancy characteristics for different types of weeds.

# Weed Identification

There are numerous books and online resources that can be used for weed identification. The following website are great resources for weed identification and provide in depth information on common weeds in New Zealand.

### Manaaki Whenua – Landcare Research

Manaaki Whenua – Landcare Research, is one of New Zealand's Crown Research Institutes, and this site provides an online weed identification tool that includes on over 650 species of weeds and over 11,000 images. The Weed Identification key should run on most browsers and can be found at:

https://www.landcareresearch.co.nz/resources/identification/plants/weeds-key

### AgPest

AgPest is designed to provide farmers with information on identifying and managing pests and weeds. In addition to providing a directory where you can search through a database of different weeds, AgPest has a weed identification tool that helps you figure out what weeds you have. Detailed information is provided on a variety of weeds, giving information about characteristics, biology, impacts, control and other information. This site can be accessed using the following link:

http://agpest.co.nz/

### Massey University Weeds Database

Massey University offers a comprehensive database covering over 70 of the most common and problematic weeds in New Zealand agriculture and horticulture. The weeds in their database are identified as the ones that cause the most problems in New Zealand pastures, crops, lawns, and gardens. This site can be accessed using the following link:

https://www.massey.ac.nz/massey/learning/colleges/college-of-sciences/clinics-and-services/weeds-database/weeds-database_home.cfm

## Weedbusters

Weedbusters is a national weed awareness programme that offers educational materials about weeds and pest plants. It is a great resource for information of the biology and control of environmental weeds. This site can be accessed using the following link:

https://www.weedbusters.org.nz/

# Weed Management Methods

There are a number of weed management methods that provide effective means of control in a hop garden and most hop gardens are effectively managed using a combination of methods.

## Tillage/Cultivation

Tillage is an effective weed management method and can reduce the need for chemical control. Tillage activities in the spring often expose weed seed to light, causing the seeds to break dormancy and germinate. Most annual weeds germinate from the top two inches of soil, so tillage and cultivation for annual weed control should be done as shallow as possible to avoid bringing weed seeds up to the surface.[xxiii] Repeated tillage weakens perennial weeds but does come with its own risks. Tillage can spread small pieces of rhizomes to new areas that were not previously infested, potentially creating larger infestations of perennial weeds in areas where they were not previously present.[xxiv] Tillage can be highly effective at killing weed seedlings, such as crabgrass.[xxv] Tillage can have a negative effect on overall soil health, and if done incorrectly can damage the hop crowns.[xxvi]

## Cover Crops

Cover crops can be used to reduce weed emergence. Planting a cover crop in autumn can reduce winter annual weed emergence and reduce weed emergence the following spring.[xxvii] Cover crops are effective for weed control because they smother sprouting weeds and act as a weed suppressant when the land is bare. Cover crops are also useful because they add nitrogen and organic matter back into the soil and increase biological activity.[xxviii]

Crops such as mustard make excellent cover crops, are often used in hop gardens. They are quick to grow and can be an economical way to add lost nutrients back into the soil in a natural way. They are generally planted in autumn and then dug into the soil prior to flowering.

## Hand Pulling

Hand pulling weeds is a tedious and labour intensive method of weed control, and is not ideal for weeds with robust tap roots or weeds that reproduce asexually, as pieces can be easily

spread. However, hand pulling can be an effective method of controlling summer annuals and can be used to manage herbicide resistant weeds.[xxix]

## Weed Fabric

Weed fabric is an effective means of weed control; however, it has many drawbacks. Weed fabric limits your ability to amend the soil or apply fungicides, and it may promote mildew and root rot.[xxx] Weed fabric is generally considered impractical on a large scale hop farm.

## Mowing/Clipping

Repeated mowing controls weeds by stressing the weeds and delaying seed production. Mowing prior to herbicide application if an effective method of weed control, as it stresses the weeds, weakening them just prior to spraying, so they are more susceptible to the herbicide application.[xxxi] Mowing should not be used for controlling weeds that have already gone to seed, as this will just spread the seeds around and create more of a weed infestation.

## Grazing

Grazing with sheep in the hop garden is a commonly used method of weed control, and is widely used to control weeds on farms in New Zealand. Grazing with sheep is particularly effective in the later parts of the growing season, when using conventional sprays is undesirable and problematic. The use of grazing as a method of weed control offers a natural option that is highly effective.

## Organic and Conventional Spray Treatments

When done properly, spraying is a highly effective method of weed control. During the growing season; however, caution should be used, as herbicides that work on broad leafed plants will be harmful to hops. Herbicides are divided into two categories, selective and non-selective. Selective herbicides kill specific weeds, whereas non-selective herbicides kill a wide range of plant species.[xxxii] Selective herbicides generally kill either broadleaf or grass type weeds, but not both. Hops are broadleaf plants, so herbicides that are harmful to broadleaf plants would also be harmful to hops, therefore caution should be used with these herbicides.[xxxiii]

Preemergence herbicides are used to eliminate weed seedlings as they germinate and sprout.[xxxiv] It is important to properly identify the weeds before using herbicides, ideally to family and

genus.[xxxv] Preemergence herbicides are used to suppress weeds early in the season. Generally, it is easier to control weeds preemergence than postemergence. Preemergence herbicides should be applied to the soil before weeds begin to emerge and grow. These herbicides function by killing weed seedlings or by preventing the seeds from germinating.[xxxvi] Rates for preemergence herbicides vary depending on soil types.

The primary goal of post emergency herbicides is to control escape weeds. These herbicides are applied to actively growing weeds, but should only be applied when green shoots, foliage or bines are not in the spray zone.[xxxvii]

# Herbicide Resistance

Herbicide resistance is becoming more common globally, and is an increasing threat in New Zealand. Herbicide resistance is when individual plants within a species develop the ability to withstand an herbicide treatment that would previously have been lethal to that species.[xxxviii]

Herbicides do not cause individual plants to develop resistance, rather, repeated pressure from herbicide use and exposure allows those plants that are less genetically susceptible to the herbicides to survive and reproduce, resulting in a larger population of plants that are resistant to a given herbicide. Herbicide resistant plants exist naturally in a population, but become an increasingly larger portion of the population with repeated herbicide use.[xxxix] As a result, the remaining weeds in a system become harder to control, because a large portion of them are resistant to the herbicides used to control them.

## Common Weeds Known to Have Developed Herbicide Resistance

As of 2007, the following weeds are known to have developed herbicide resistance in New Zealand.[xl]

### Fathen – Chenopodium Album

Fathen is a summer annual and was the first known weed to develop herbicide resistance in New Zealand.



[xli]

## Willow Weed – Persicaria Maculosa

Willow weed is an annual that thrives in moist conditions, often in newly planted crops in the spring. Willow weed is susceptible to some herbicides, and others only suppress it.[xlii]


[xliii]

## Nodding Thistle – Carduss Nutans

Nodding Thistle is a biennial weed that can be difficult to distinguish from a Californian thistle or Scotch thistle. Herbicide resistance has been found for Nodding Thistle in some parts of New Zealand. Research is being undertaken by Massey University to study this.[xliv]



[xlv]

## Giant Buttercup – Ranunculus Acris

Giant Buttercup infestations are notoriously difficult to control and are prevalent throughout New Zealand, causing major problems in dairying regions. Herbicide resistance has been a problem in New Zealand since the 1980s.[xlvi]



[xlvii]

## Black Nightshade – Solanum Nigrum

Black Nightshade has been found resistant to some herbicides in New Zealand.



[xlviii]

## Slender-Winged Thistle – Carduus Pycnocephalus

Slender-Winged Thistle, along with other thistles, developed a resistance to selective herbicides in the 1980s.

[xlix]

## Chilean Needle Grass – Nassella Neesiana

Chilean Needle Grass is an invasive weed that takes over pastures and has developed a resistance to some herbicides.

[l]

Chickweed – Stellaria Media

Chickweed is tolerant of a number of herbicides.



li

## Factors that affect herbicide resistance

- Frequency of use of herbicides. The number of applications, the number of years of herbicide use.
- Mode of action of herbicides.
- Weed biology and density.

## Reducing the risk of developing herbicide resistance

There are a number of practices that can help reduce the risk of developing herbicide resistance.

- Rotate between modes of action groups across years.
- Calibrate equipment and apply herbicides to manufacturers recommendations.
- Keep accurate herbicide application records.

Herbicide resistance can be prevented with good weed management practices. These include using a diverse range of weed control strategies. It is important to incorporate non-chemical controls into your weed management programme. Lastly, it is critical to develop a weed management programme that does not rely on a single solution to control weeds.

# Planning a Weed Management Programme

When developing a weed management programme there are several factors that are important to consider. These include, weed species, tillage, row spacing, irrigation, cover crops, and herbicides.[lii] It is important to determine the types of weeds present in the hop garden, as this affects decisions about treatment and timing for weed control. Accurate identification is also important to determining an effective and economical treatment programme.[liii]

### Hallmarks of a Good Weed Management Programme[liv]

- ✓ Regular and timely mechanical cultivation
- ✓ Cover crops
- ✓ Mowing or removing weeds before they set seed
- ✓ Grazing
- ✓ Preemergence herbicides
- ✓ Postemergence herbicides

### Prevention

Prevention is critical to an effective weed management programme. Weeds can be introduced to a hop garden from many sources, including, wind, birds, irrigation water, equipment, and new plants. Weed management best practices help to reduce the introduction of weeds into the hop garden. Some prevention strategies include, controlling weeds around hop garden borders, cleaning equipment before moving from one field to another, screening irrigation water, and ensuring that new plantings do not contain weed seeds.[lv]

### Management

Ongoing weed management in the hop garden is important because it is much easier to control new weeds before they seed.

Winter annual weeds are often removed in late winter and early spring with herbicides or cultivation. Glyphosate controls most emergent weeds and should be applied before hop emergence.[lvi]

## Pest and Disease

Weed control should be part of an integrated hop pest management programme. Proper weed control is important to preventing disease and controlling pests in a hop garden. Excessive weeds can provide and environment for disease and insects to thrive, especially during the period when the hops are not actively growing.[lvii]

The Hāpi Brewing Success programme between Hāpi Research Ltd and the Ministry for Primary Industries is driving benefits for New Zealand's premium hops and craft beer industries through an advanced market-led hop breeding programme, precision farming and processing techniques, and international market collaboration with leading craft brewers.

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